Section 3.10

Nitric Acid Handling

Contents

Contents

Section 3.10
Nitric Acid Handling

3.10.1 Work Identification

The report demonstrates an application of the integrated safety-management process to an example of nitric acid handling. This report focuses on the control of hazards associated with a leakage of nitric acid during delivery at the wet chemical storage area.

This example was chosen to present the assessment of a hazardous chemical event, and demonstrates the first two principles of the Process Safety Management Program as defined in DOE/RL-96-0006 General Process Safety Principles (DOE-RL 1998c), namely, to develop process safety information and to perform a process hazards analysis.

In evaluating the hazards associated with nitric acid handling, commercial industry practices were researched, and along with regulations, they were adopted as a mature control strategy. Further strategies were evaluated to determine if they would be cost effective in further reducing the hazard or consequences.

3.10.1.1 Key Process and Design Parameters

3.10.1.1.1 Process

The nitric acid system, as described in the *Initial Safety Analysis Report* (ISAR) (BNFL Inc.1998c), is provided to receive, store, and distribute 12.2 molar (M) nitric acid to the pretreatment facility for use in the pretreatment processes for the low activity waste (LAW) and the high level waste (HLW), and for flushing of equipment. The pretreatment process for the vitrification of waste at TWRS-P requires both 2M and 0.5M nitric acid. Nitric acid at a concentration of 0.5M is used primarily in the process for removing cesium and technetium from the pretreatment ion exchange resins. The cesium and technetium elution solutions are evaporated to recover the nitric acid for reuse. Nitric acid is also used at a concentration of 2M for back flushing the ultrafilter units and washing the HLW melter offgas treatment filters. For initial startup of the nitric acid recovery process, a 5M solution of nitric acid is required (see Figure 3.10-1).

Nitric acid is initially obtained and stored at a concentration of 12.2M, then transferred to the process buildings where it is diluted to the required process concentration. Nitric acid is used at the rate of approximately 39 US gallons per day (148 L/d) of 12.2M acid (Eager 1999). The concentration of 12.2M nitric acid was selected for use at TWRS-P based on both the process explicit requirements for the pretreatment of the waste and other possible needs such as equipment decontamination and cleaning. Nitric acid in 12.2M concentration is a commercially supplied concentration and available for delivery in the quantities required.

The Cold Chemical System Description (BNFL Inc. 1997a) describes the chemical storage systems and the chemical storage area. A 5,000-gallon (19 m^3), type 304L stainless steel tank is provided for receipt and storage of nitric acid as described in the ISAR. The tank is located on a concrete pad within a catch basin (berm) surrounding the tank. The catch basin is coated or lined concrete designed to contain the contents of the tank and to exclude the ingress of liquids from other tanks in the chemical storage area. All components of the system are designed to be compatible with 12.2M nitric acid. The capacity requirement of the storage tank is being revisited and is an **Open Issue** at this time. However, the tank capacity does not directly impact the hazard evaluation in this example since a spill from a large tanker truck is assumed.

At this point in the design, the size of the line, the pressure of the system during transfer, and the method of inducing the flow have not been established. **Open Issue**. The storage tank is at atmospheric pressure and is vented to the atmosphere in this open building. An **Open Issue** has been identified to provide a vent design that assures that NO_x are not released.

3.10.1.1.2 Wet Chemical Storage Area

The wet chemical storage area is a single-story structure with its components at grade level. The area has storage facilities for nitric acid, sodium hydroxide, strontium nitrate in dry form and in solution, ferric nitrate in dry form and in solution, sodium nitrite in dry form and in solution, a styrene-based ion exchange resin, and a polymerized ligand resin stored in packages or drums. The chemical tanks are housed in an open-sided, roofed structure for weather protection. The tanks for each type of chemical have catch basins to collect any tank leakage and prevent the spread of the chemical solutions to other areas of the facility. Dry chemical storage is also located in the open-sided portion of the area, but separated from the liquid tanks. The ion exchange resin storage area is enclosed, with temperature and humidity control.

3.10.1.1.3 Nitric Acid Delivery and Unloading/Transfer

Nitric acid is delivered to the nitric acid unloading station by tanker truck. Nitric acid is unloaded from the supply truck at the unloading station located at the side of the wet chemical storage area and transferred to the nitric acid storage tank. The currently envisioned delivery schedule would require that only one tanker be on site at any one time. **Operational Assumption.**

The mechanism for transferring the nitric acid from the tanker to the storage tank was left as an open item from the Part A conceptual design work (BNFL Inc. 1997a). Subsequent to that design work, the mechanism has been determined to be an air-driven diaphragm pump. **Design Assumption.** This was selected, giving consideration to issues discussed in the preliminary safety review (BNFL Inc.1998e), that it be a system that would not require the workers to be in close proximity of the tanker during the unloading of acid. The use of compressed air as the transfer mechanism was dismissed since monitoring both storage tank and tanker during a transfer of fluid would necessitate a complicated design. The diaphragm pump, which would allow for remote operation, would not introduce the potential hazard of a pressurized tanker. Additionally, when the pump is not operating, the pump itself acts as a stop valve, preventing the flow of fluid through it. The draft system description proposed the use of a power take-off pump on the truck, however, that would not allow for remote operation.

3.10.1.1.4 Relevant Design Parameters

The parameters (**Design Assumptions)** important to the postulated event evaluated in this example are:

- The truck capacity of 5,000 US gallons (19 m^3), which is based on industrial experience for acid delivery, is the potential spill volume. The storage tank, which would be filled from the top, would typically be low in inventory prior to delivery. During any transfer operation and credible spill scenario at the unloading station, the contents of both the tanker truck and storage tank could not simultaneously empty.

- The nitric acid is commercial grade and at a concentration of 12.2M, as stated in the Basis of Design (Page and others 1998). Commercial grade nitric acid (also known as brown nitric acid) contains dissolved NO_x and vents NO_x when sprayed or heated. During the filling of the storage tank, acid vapors and NO_x would be released from the tank vent. Although not pertinent to this spill scenario, a vapor return on the tank vent with a small scrubber would preclude toxic gases and vapors from being released during a normal transfer. The tank vent design will be carried as an **Open Issue** for engineering resolution.

- The nitric acid and equipment are at ambient temperature at the time of the spill. The truck-unloading station is open to the outdoors.

- The pressure in the system is assumed to be sufficient to cause a spray of acid to impact the immediate area of the unloading station.

- The tanks in the wet chemical storage area have catch basins or berms to prevent spread or mixing of chemicals.

- The building and the unloading station are open-sided, so air is free to circulate.

- The unloading area has a coated concrete apron with retention berm and a sump. Berm dimensions are approximately 30 ft x 45 ft (9 m x 14 m).

- The safety equipment required and specified by a Material Safety Data Sheet (MSDS) for nitric acid is in place.

- Design features required by regulation or law are credited and discussed in this report.

3.10.1.2 Interfaces

This activity is at the beginning of the process for using nitric acid. The interfaces between the tanker and the storage tank do not, under normal circumstances, impact the other processes within the TWRS-P facility.

The tanker will back into an unloading station, that is bermed, and use a flexible hose to manually hook up to the unloading station. The transfer line will be hard-piped from the unloading station to the storage tank. The storage tank will be situated in its own berm; and the transfer line will penetrate neither the berm for the storage tank nor the berm for the tanker truck. **Design Assumption.** The operator for the wet chemical storage area will be located in an office space within the temperature and humidity controlled area for the resin storage. From this vantage, the operator will be able to view the unloading station. The driver and the operator will both be in attendance during the transfer. Access to the resin storage area is through a roll-up door or personnel door from the outside, or through an airlock from the pretreatment building.

A major consideration for chemical spills is the location of building ventilation intakes, and especially the control room intake(s). The current plan is to locate the control room for the process of pretreatment and vitrification in the administration building, which is currently located on the other side of the pretreatment building from the wet chemical storage area (see Figure 3.10-2). The details of the HVAC system design for the administration building are not firmly developed, and the location of the intake(s) for control room ventilation has not been fixed, but an analysis of the control room has been performed based on the currently envisioned design. See Section 3.10.2.3. Relevant interface parameters are as follows:

Distance from spill to control room intake	430 ft (132 m)
Control room area	1,600 ft^2 (149 m^2)
Control room height	10 ft (3 m)
Control room ventilation	6 air changes per hour
Control room make-up rate	10% of total ventilation
Pretreatment building height	70 ft (21 m)
Pretreatment building length	434 ft (133 m)
Pretreatment building width	216 ft (166 m)

3.10.1.3 Operating Environment and Setting

3.10.1.3.1 Setting

The wet chemical storage area is adjacent to the pretreatment building. The area is described in Section 3.10.1.1.2.

3.10.1.3.2 Operating Environment

With the unloading station being located outdoors, it is subject to the ambient conditions of the site. Nitric acid deliveries could be made during any season of the year.

The *Basis of Design* (Page et al. 1998) lists the parameters of the Hanford Site climatology. Pertinent conditions for this evaluation are the temperature range, relative humidity, and wind speed. They are as follows:

- Temperature Range: -23 °F to 113 °F
- Relative Humidity: 5% to 100%
- Average Wind Speed: 7.6 mph at the 50 ft elevation
- Peak Wind Gust: 80 mph at the 50 ft elevation
- Mean Annual Precipitation: 6.3 inches
- Maximum 1 day Precipitation: 1.6 inches

3.10.1.4 Applicable Experience

Experience and advice on designing a chemical unloading station for nitric acid were solicited from several sources, as follows.

3.10.1.4.1 British Nuclear Fuels plc Experience

Experience from the use of chemical unloading stations in the UK is directly applicable to this situation.

A small number of chemical spill incidents have occurred over the years in BNFL Sellafield and Springfield Plants. They have been primarily in the more complex chemical off-loading and distribution systems. Only one of these incidents related to an incorrectly made supply tanker connection. That system used tanker pressurization (with compressed air) for unloading the tanker. Experience with the simple bulk chemical (i.e., acids, solvents and alkalis), receipt facilities is good. At the inactive tank farm at Sellafield Site Services, the nitric acid delivery system allows for delivery from both railcar and highway tanker. For delivery by highway, the tanker is staged in a bermed area prior to the transfer. The tanker is not pressurized during the transfer. Acid is gravity fed to the inlet of a permanent onsite pump that transfers the acid to the storage tank from the tanker.

3.10.1.4.2 Hanford Experience

The acid unloading station and process was reviewed at the 300 Area Treated Effluent Disposal Facility (TEDF). The acid delivered to this facility is 93% sulfuric acid. The tanker type specified for delivery of the acid is a bottom-unloading 5,000-gallon tanker. The unloading station is outdoors and uncovered, with a concrete pad where the tanker unloads the acid to a storage tank. The pad is sloped to a sump area that is covered by a grating. The sump is cleaned and drained prior to the tanker unloading the contents of the tank. In order to provide reproducible delivery of the acid and control of the process, a power take-off pump available on the tanker is not used for transferring the acid. The transfer mechanism for the acid is to provide air pressure to fill the hose and flood the suction of a transfer pump that then, pumps the contents to a storage tank.

The DOE Internet site (http://tis.eh.doe.gov/web/chem.safety) was accessed to determine what types of incidents involving chemical spills have occurred on the Hanford Site. In reviewing the past 3 years of reports, most of the incidents dealing with suspected chemical exposure were from improper hose connections or laboratory work, although laboratory accidents are not directly applicable to this example.

3.10.1.4.3 Industry Experience

The Bechtel Process Environmental Department was contacted to determine the standard practices for designing nitric acid unloading stations. Recommended features included a purge system for the unloading line, an excess-flow shutoff valve, and a remote access emergency shut-off. Required features included eye-wash stations, safety showers, personal protection equipment such as eye-goggles and chemical suits, an impervious surface at the unloading dock, a spill collection method, guard posts or other protective barriers which limit truck movement, and splash guards to protect the worker. Additionally, fire control needs to be addressed for the facility.

3.10.2 Hazard Evaluation

The evaluation team performed a review of previous hazard analyses, which is summarized below. The *Hazard Analysis Report* (HAR) (BNFL Inc. 1997b) identifies the hazardous characteristics of process chemicals onsite at the TWRS-P facility, and presents an interaction matrix for the chemicals. It also lists contact with nitric acid as a hazard, but does not directly address nitric acid spills in the wet chemical storage area.

The *Initial Safety Analysis Report* (ISAR) (BNFL Inc. 1998c, Section 4.7.2.9) states that "a spill of nitric acid, caused by leakage of lines during filling or delivery to the facility, or by a catastrophic failure of the tank, could result in inhalation of toxic fumes and vapors by workers or the public." The catastrophic failure of the storage tank is then evaluated as the bounding spill for this event. The catch basin surrounding the tank is credited to contain the tank's contents. The results of the ISAR evaluation are that the maximum exposure of the public to acid fumes is less than the TEEL-2 limit (Craig 1998), but exposure of the workers and co-located workers exceeds the exposure standard. The ISAR also states that the "hazards associated with bulk cold chemical storage were assessed in a separate safety review"; this review is discussed below (BNFL Inc.1998e).

The evaluation of hazardous chemical handling at the wet chemical storage area will be properly carried out by a facility evaluation, taking into account the detailed layout of equipment and components, and the totality of chemicals and materials associated with the area. **Open Issue.**

A preliminary safety review (BNFL Inc. 1998e) was performed on an early conceptual design proposal for cold chemical storage (Roberts 1997). That review was conducted to indicate hazards and concerns that would need to be addressed via more formal means early during fulfillment of Part B of the TWRS-P contract (DOE-RL 1998b) when more design detail becomes available. There is no additional design detail available at this time. While fully utilizing that former report, the example developed in this report focuses on the receipt of only one chemical. As such, it is a limited interim evaluation of only one of the hazards that will be evaluated in depth, as part of a facility study covering all operations, equipment, and chemicals/materials in the area, when a more mature design is available. Nonetheless, this example does provide valuable design direction that will be considered during the design effort.

3.10.2.1 Hazard Identification

3.10.2.1.1 Nitric Acid Properties

As previously stated, the process material is 12.2M nitric acid.

The following information was taken from the MSDS (Mallinckrodt Baker Inc. 1996) for nitric acid.

Hazardous Properties:

- Corrosive
- Reactive
- Oxidizer
- Poison

Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PEL):

- Time Weighted Average (TWA) 2 ppm
- Short Term Exposure Limit (STEL) 4 ppm

Health Effects:

- Inhalation of vapors can cause breathing difficulties and lead to pneumonia and pulmonary edema, which may be fatal.

- Ingestion can cause immediate pain, burns of the mouth, throat, esophagus, and gastrointestinal tract.

- Skin contact can cause severe skin burns, deep ulcers, and stain skin yellow.

- Eye contact by vapors may cause eye damage; contact may cause severe burns and permanent damage.

- Long-term exposure to concentrated vapors may cause lung damage.

Fire:

- Nitric acid is not combustible; however, nitric acid is a strong oxidizer and the heat of reaction may cause ignition. (This is unlikely unless mixing with another solution.)

- Nitric acid reacts explosively with combustible organic or readily oxidizable materials.

- Water spray may be used to cool fire exposed containers, however water should not get inside container.

Stability:

- Material is stable under ordinary conditions of use and storage.

- When heated to decomposition, emits toxic nitrogen oxide fumes and hydrogen nitrate. Will react with water or steam to produce heat and corrosive fumes.

- Incompatible with most substances, especially strong bases, metallic powders, carbides, hydrogen sulfide, and combustible organics.

3.10.2.1.2 Resultant Hazards

For this evaluation, the hazard arises from the spill of a hazardous chemical, nitric acid. The spill could expose facility workers to direct contact with the nitric acid, expose workers and possibly co-located workers and the public to inhalation of toxic fumes and vapors, create interactions of nitric acid with other materials or chemicals (i.e., NO_x generation, fire), and release nitric acid to the environment. It could also cause secondary effects by damaging equipment (disabling or spurious actuation) in the vicinity of the spill, and potentially affect other plant areas by making them inaccessible due to the toxic cloud being drawn into the ventilation intakes of the plant buildings.

3.10.2.2 Event Sequence

The initiating event in this example is the spill of nitric acid during delivery by tanker truck to the wet chemical storage area, due to either equipment failure or human error. During hook-up or disconnection of the hose from the tanker to the connection station, credible spills could be caused by leaks at connection fittings, which might be caused by human error, fit-up problems, gasket leakage, or minor damage to fittings; fatigue failure or damage to flexible hoses; or failure of welds on the tanker or piping. A leak that cannot be isolated could conceivably empty the entire contents of the tanker.

The sequence postulated for this example includes:

1. A break of a hose, pipe, or fitting causes a leak at the unloading station, potentially emptying the tanker

2. Spray hits worker

3. Vapor exposes worker and beyond

4. Leakage reaches ground

   - Exceeds the reportable quantity (1,000 lbs per the MSDS)
   - Environmental release (surface or groundwater)
   - Fire potential because of integration with flammable material

5. Leakage reaches dry chemicals and resins

   - Generation of NO_x and possibly other toxic gases
   - Fire potential because of integration with flammable material

6. Potential to spray electrical and instrument equipment (left as **Open Issue** for future resolution)

   - Generation of NO_x gases
   - Equipment failure

7. Toxic gas enters buildings through ventilation intakes (left as **Open Issue** for future evaluation)

Due to the lack of detailed design information, specific information relative to exact location of the nitric acid receiving station and the types of equipment/components that a potential spill could impact are not addressed, and will be carried forward as an **Open Issue** for future evaluation. However, a major design consideration identified in the Preliminary Safety Review (BNFL, Inc. 1998e) is the use of berms, or other separation features, to prevent interaction between the various chemicals and materials stored in the facility. These features are considered effective, and will be carried forward to ensure that, as the design progresses, interactions associated with incompatible chemicals or materials will be precluded. **Design Assumptions.** This example does address the methods used to prevent the nitric acid from spraying or spilling onto other chemicals, but recognizes that passive features (e.g., berms) for storage of the other chemicals are already included in the design that help accomplish this.

3.10.2.3 Unmitigated Consequences

A preliminary calculation was performed to determine the toxic chemical consequences for a 5,000 US gallon spill of 12.2M nitric acid. The Bechtel Standard Computer Program TOXGAS, NE319 was used. This calculates the distance at which the concentration falls below toxic limits. In addition, consequences to operators in the central control room in the administration building were examined. (Schulz 1999).

The toxic endpoint is the distance from the source at which the hazardous chemical concentration drops below the limit value. Per the Safety Requirements Document (SRD, BNFL Inc. 1998D), the limit value in this case is the Emergency Response Planning Guidelines-2 (ERPG-2) limit established by the American Industrial Hygiene Association (AIHA 1988). ERPG-2 limits for nitric acid have not yet been established by AIHA. However, the DOE subcommittee on Consequence Assessment and Protective Action (SCAPA) has adopted Temporary Emergency Exposure Limits (TEELs) for chemicals for which official ERPGs have not yet been developed. The TEEL-2 for nitric acid is 15 ppm (Craig 1998).

The toxic chemical consequences to the control room operators use the OSHA PEL TWA limit of 2 ppm. This lower limit is appropriate for use for workers that may be subject to the nitric acid cloud for extended periods of time.

Input Parameters. **Design Assumptions.**

Nitric acid concentration	12.2M (61% by weight)
Spill volume	5,000 US gallons (19 m^3)
Ambient Temperature	113°F (45°C)
Berm dimensions	30 ft x 45 ft (9 m x 14 m)
Distance from spill to control room intake	430 ft (132 m)
Control room area	1,600 ft^2 (149 m^2)
Control room height	10 ft (3 m)
Control room ventilation	6 air changes per hour
Control room make-up rate	10% of total ventilation
Pretreatment building height	70 ft (21 m)
Pretreatment building length	434 ft (133 m)
Pretreatment building width	216 ft (166 m)

Two atmospheric conditions were considered:

1. Stability class D with a wind speed of 4.5 mph (2 m/s). This condition is suggested as typical for accidental spill consequence determination.

2. Stability class F with a wind speed of 2.2 mph (1 m/s). This is the most limiting condition, typically used to determine toxic chemical consequences at nuclear power plants.

The effect of buildings or intervening equipment was ignored in the calculation of the limiting distance. The effects of the pretreatment building on the cloud concentrations were considered in the control room operator toxic consequence analysis.

Control room concentrations were calculated up to eight hours after the spill assuming no mitigating intervention during this time. In other words, the calculation made no allowance for any mitigating features in the control room ventilation system.

The control room air intake was assumed to operate continuously during the course of the accident.

Results: **Distance to 15-ppm TEEL limit:**

Stability Class D, 4.5 mph (2 m/s) wind	237 ft (72.4 m)
Stability Class F, 2.2 mph (1 m/s) wind	542 ft (165.1 m)

These results demonstrate that the exposure could exceed the limit for the facility worker and the co-located worker, but not for the public.

Nitric Acid Concentrations in the Control Room:

Stability Class D, 4.5 mph (2 m/s) wind	1.19 ppm
Stability Class F, 2.2 mph (1 m/s) wind	1.63 ppm
OSHA PEL TWA	2 ppm

The conclusion is that habitability of the control room can be achieved for at least 8 hours without isolating the air intake or other mitigating measures (i.e. 8 hours is not a point in time at which a limit is breached). This is based on preliminary design information for the control room, which is subject to change. If necessary, design features to address toxic cloud concerns can be incorporated which can include, for example, relocation of the intake; multiple separated ventilation intake locations; detection and isolation capabilities of the intakes; or remote shutdown capabilities if the control room has to be evacuated. These are left as an **Open Issue**. In addition, the impact to personnel in other facility buildings has not been evaluated at this time. This is also an **Open Issue**. Similar control strategies can be applied to the other buildings if necessary.

3.10.2.4 Frequency of the Initiating Event

The consequences, however, are of a nature that warrants reasonable and prudent measures be taken to prevent the accident or mitigate the consequences of the accident. The chemical unloading station proposed at TWRS-P will be consistent with similar unloading stations throughout non-nuclear industries. There are accepted codes and standards that are employed to reduce the potential of accidents and reduce the severity of accidents throughout industrial sites, which represent a mature control strategy. These practices will be adopted. Therefore, frequency estimates are not required to be calculated for the chemical hazard evaluation. Additional control strategies are evaluated in this report and adopted, where worthwhile, to ensure the safety of both workers and the public.

3.10.2.5 Common Cause and Common Mode Effects

The most credible common cause and common mode effects that would increase the likelihood of nitric acid spills during the unloading sequence is a plant-wide breakdown in administrative controls that could result in incidents such as:

- The wrong tanker arriving
- Wrong hoses or couplings used
- Incorrect operation

A plant-wide problem such as this would be highly unlikely, and would have significant precursor events that would indicate such problems, and provide opportunities to correct such problems.

3.10.2.6 Natural Phenomena Hazards and Man Made External Events

3.10.2.6.1 Natural Phenomena

Natural phenomena hazards and their treatment on a plant-wide basis are included in section 2.10. **Design Assumption.**

The delivery of nitric acid is such that it can be postponed or ceased during many of the natural phenomena hazard events listed in section 2.10. The major event that could affect the transfer of nitric acid from a tank and happen concurrently with the transfer without warning would be a seismic event. This event could introduce the possibility of chemical interactions during a nitric acid spill that would increase the consequences of a tanker unloading accident.

A seismic event could impact all the storage tanks and the nitric acid transfer system during the same event. However, the frequency of the event is not significant in comparison to the hazard; normal industry practice is to design to UBC seismic standards. Therefore, this facility will be designed to UBC seismic standards, which is sufficient since failure will not have radiological consequences as the leaked acid will not affect equipment, protecting against radiological release. **Design Assumption.**

3.10.2.6.2 Man Made External Events

Man made external hazards and their treatment on a plant-wide basis are discussed in Section 2.10. Most events such as aircraft crash do not uniquely affect this event, so are not considered further here. Vehicle collisions could affect this event, so adequate crash protection will be discussed during selection of the control strategy, in addition to that recommended by industry practice.

Performance of a complete hazard evaluation for the wet chemical storage area, which would include a more detailed assessment of the facility with respect to the applicable design basis events, remains an **Open Issue**.

3.10.3 Control Strategy Development

3.10.3.1 Controls Considered

Controls required by current Federal and/or State regulations are listed here for completeness. They will become part of the final design. Since they are mandatory, they are not included in the evaluation process for acceptance or rejection.

The following control strategy elements were identified for consideration as potential safety features to prevent or mitigate the consequences of a nitric acid spill.

- Elements Required by Law

  <u>Tanker Truck Standards.</u> The truck that transports and delivers the nitric acid to the site must, by law, meet DOT safety standards. This activity is well understood and highly regulated. Use of a fully qualified trucking firm and verification of truck and operator documentation are requirements. [49CFR171-180]

  <u>PPE.</u> Protective clothing and equipment protect the worker from direct contact with sprays or splashing nitric acid. Self-contained breathing apparatus (SCBA), where necessary, provide protection from toxic fumes. [29CFR1910.132]

  <u>Spray or Splash Shields.</u> Shields prevent interactions with other chemicals and materials, prevent contamination of nearby equipment, and protect personnel. [29CFR1910.132]

  <u>Eyewashes and Showers.</u> In the event of contact with the nitric acid or vapors, eyewashes and showers mitigate the consequences to the worker. [29CFR1910.151(c)]

  <u>Emergency Planning Procedures.</u> Emergency procedures mitigate consequences to TWRS-P and Hanford Site workers. [29CFR1910.119]

- <u>Change Process.</u> If the plant process can be changed to eliminate the need for nitric acid, the hazards associated with a nitric acid spill would be eliminated.

- Eliminate Transfer Process. If the plant process requirements were changed to require less nitric acid, individual “drop” tanks (barrels or individual containers of nitric acid) could be used, eliminating or reducing the risk of large spills. This may introduce new hazards, however, such as dropping a tank.

- Reduce Nitric Acid Concentration Requirement. The current process requirement is for 5M nitric acid. Delivery is based on 12.2M. If 5M can be delivered, it should reduce the hazard somewhat, although it may require greater inventory or more deliveries.

- Smaller, More Frequent, Deliveries. Smaller deliveries would limit the maximum size of a potential spill, but would require more deliveries.

- Enclose Unloading Area. Providing a drive-in building for unloading would prevent the spread of both the spill and associated vapors. Such a building would require its own ventilation, be very costly and might create new hazards related to interior spaces.

- Positive Locking Couplings. The connections for the flexible hose from the tanker to the unloading station hard pipe should be via positive locking, high quality sealing couplings.

- Excess Flow Shutoff Valve. An excess flow shutoff valve would isolate the tanker from a large downstream leak without complicated interlocks.

- Remote Access Emergency Shutoff. A remote access emergency shutoff would allow an operator to remotely stop the transfer pump.

- Sleeved Hoses and Fittings. Sleeving would provide a secondary barrier to leakage, or direct the leakage to the bermed area.

- Fittings and Connections with a Pump Start Interlock. A pump start interlock would prevent the transfer from beginning, or stop a transfer, if connections were not properly made.

- Berms. Berms prevent interactions between adjacently stored materials, limit leakage to the ground, and limit the area of the spill. They will be coated or lined to be compatible with the chemicals they must hold.

- Truck (unloading area) Sump with Sump Pump. A truck sump would prevent interactions with surrounding facilities and equipment, and prevent leakage to ground. It could also limit the evolution of vapor by limiting the surface area of a developing pool of nitric acid. The sump pump would facilitate recovery from a spill. Trenches, designed for the same purpose, are considered the same as sumps, since they collect the leakage and can reduce the surface area of the spill. Trenches can also serve the purpose of a berm in certain applications.

- Underground Tank (In Place of Sump). Use of an underground tank would limit the evaporation of nitric acid and thus limit the evolution of toxic vapor. However, this would introduce additional hazards, such as those associated with tank pressurization or those resulting from the interaction of nitric acid with contaminants that may be in the tank.

- Leak Detection and Automatic Shutoff. Leak detection tied to an automatic shutoff of the transfer pump, compressor, or valve could reduce the volume of acid leaked.

- Leak Detection in Sump or Tank, with Alarms. This would warn personnel if a spill were detected collecting in the sump. Actions would follow as outlined in an Emergency Response Procedure.

- Acid Compatible Pump (Process Hardware). To prevent failures that could lead to leakage, all pumping equipment and related hardware (including hoses, gaskets, etc.) must be compatible with nitric acid. These design considerations are considered an inherent part of any viable design, and therefore are not evaluated further. In addition, maintenance programs, inspection, testing, erosion/corrosion, etc. are all similar elements of a successful control strategy that is common to the entire facility and not separately identified or evaluated here.

- Physical Barriers. Physical barriers located at the unloading station would prevent the tanker truck, or other heavy machinery, from impacting facility transfer piping and equipment.

- Forced Ventilation. Forced ventilation in the unloading area would help prevent toxic vapors from collecting in the area.

- Truck Speed Limits. Truck speed limits would reduce the potential for truck accidents that could damage the tanker and create a spill. Along the same lines, the truck routing near the facility should be controlled to preclude a potential spill near building ventilation intakes or other sensitive areas or equipment. Since this example is specific to the transfer activity (after the truck has been parked), these control strategies do not directly affect this example, and will not be evaluated further.

- Spotter During Truck Parking. A spotter would assist the truck operator during parking and reduce the risk of accidents. This does not directly affect this example however, and will not be evaluated further.

- Buddy System. A buddy system, whereby at least two operators are required to be present during nitric acid transfer to watch out for mishaps and assist each other if needed, will reduce the risk of injury.

- Clear and Complete Written Unloading Procedures. Unloading procedures would increase the likelihood that the correct steps are taken to safely unload the truck. This type of control is considered mandatory for an activity like this, but will be included in this evaluation to ensure that it is identified. However, other basic controls that are equally important, such as using personnel that are fully qualified and trained, are not separately identified as individual control elements since they are understood to apply to major facility activities.

- Monitor Storage Tank Level. Monitoring acid level in the tank would help prevent potential overfilling during transfer. This requires a level indicator that functions during the filling operation.

- Overfill Detector and Alarm. A separate detector on the storage tank, set below overfill, could alarm and alert operators of a potential overfill condition.

- Good Housekeeping. Risk of fire hazard would be reduced in the area around the unloading station by keeping it free of material that could pose a fire risk if it were exposed to nitric acid.

- Cleaning Out Sumps; Emptying of Water and Debris. Cleaning out the sumps would prevent potential interactions of the nitric acid with organic and other incompatible materials.

- Flush Area. Flushing the unloading area would prevent interactions between nitric acid and other material in the area.

- Restrict Personnel Access During Transfer. Restricting access would limit the number of personnel exposed during a potential spill.

- Unique Connections for Acid and Caustic. Unique connectors for acid and caustic would reduce the chance of connecting the tanker to the wrong tank, an event that could lead to a hazardous interaction. This consideration does not affect this example, but would be captured by a hazard analyses for the facility.

- Dedicated Acid Offloading Area. A dedicated offloading area for nitric acid would reduce potential interactions with other types of chemicals at the facility. This does not affect the example, but would be captured in a full hazard analyses for the facility.

3.10.3.2 Control Strategy Selection

Control strategy selection was based on a two-step process: first, clearly unrealistic control elements were deleted; second, engineering tradeoffs were considered to further down-select the options, and a preferred control strategy was selected.

3.10.3.2.1 Step 1 (Initial Screen)

The merits of each of the potential controls described above (except those mandated by law) were considered primarily against the following set of criteria:

- Effectiveness
- Practicability
- Reliability
- Demonstrability
- Compliance with laws and regulations
- Ability to comply with DOE/RL-96-0006 General Process Safety Principles (DOE-RL 1998c).

The top-level principles for process safety are contained in Section 5 of DOE/RL-96-0006. These principles are primarily related to the programmatic measures that make up the process safety management program that is implemented for process hazards. These measures will become part of the operation of the facility. Design of the facility must accommodate effective implementation of the measures. Measures such as operating procedures, training, and emergency planning will all be part of plant operation. Process safety information will be available, and a mechanical integrity program will be in place during operation. The control elements proposed are consistent with these top-level principles.

The results of the process are shown in Table 3.10-1.

Table 3.10-1. Nitric Acid Handling – Selection of Control Strategy Elements

Control	Advantages	Disadvantages	Compliance with Top Level Principles	Further Consideration in Control Strategy
Change process - eliminate use of nitric acid	Eliminates nitric acid onsite.	Not viable at this time. Replacement process may introduce worse hazard.	No - Unknown impact	No - This is not considered viable.
Eliminate transfer process – use drop tank	Eliminates spill during tanker truck delivery.	Creates new hazards. There is the potential for a handling accident during barrel or “drop” tank delivery. Nitric acid still has to be introduced into the nitric acid system via connections or emptying into tanks. May require more deliveries.	Yes.	No
Reduce Nitric Acid Concentration Requirement	Lower concentration of acid reduces the consequences of the hazard.	May require greater inventory. Cost and availability will be adversely affected since 12M is the lowest standard concentration from suppliers.	Yes	No
Smaller, more frequent deliveries	Reduces spill size.	Increases number of deliveries. Does not eliminate hazard.	Yes	**Open Issue**
Enclose Unloading Area	Contains spill, including vapors.	Does not eliminate hazard. High cost. Would require high volume ventilation system.	Yes	No
Positive Locking Couplings	Helps prevent spill or leakage at connection.	None	Yes	Yes
Excess Flow Shutoff Valve	Reduces spill size. Automatic. Common practice within industry	None	Yes	Yes
Remote Access Emergency Shutoff	Reduces spill size for leaks downstream of transfer pump.	Requires operator action.	Yes	Yes
Sleeved hoses and fittings	Provides two barriers to leakage in the most susceptible hardware. Passive.	Impractical. This only mitigates spray risk and would impose operability problems which could increase risk of poorly made connections. Creates wastes (i.e., failed sleeves)	Yes	No – Impractical (see additional discussion below)

Table 3.10-1. Nitric Acid Handling – Selection of Control Strategy Elements

Control	Advantages	Disadvantages	Compliance with Top Level Principles	Further Consideration in Control Strategy
Fittings and connections with pump start interlock	Prevents pump start if connections not properly fitted up. Prevents high-pressure leaks at connections.	Does not prevent leaks, especially upstream of pump. Complicates design and operation. Could possibly be overridden if malfunctioning. Active feature, difficult to maintain and implement with subcontractor equipment.	Yes	No – Impractical (see additional discussion below)
Berms	Confines spill, limits surface area for evaporation. Prevents release to ground. Common practice within industry.	None	Yes	Yes
Truck sump with sump pump	Effectively reduces area for evaporation, further confines spill, facilitates use of alarm (see below). Common practice within industry.	Must be clean of water and debris (see below).	Yes	Yes
Underground tank/vault – with surface collection and drainage system.	Effectively contains spill, limits evaporation and thus vapor exposure.	Capital cost, creates new hazard of interactions with debris or other chemicals if tank is not clean, risk and cost does not seem warranted at this time.	No – Difficult to maintain.	No – Impractical (see additional discussion below)
Leak detection in sump or drain with auto shutoff of transfer pump	Stops transfer if leak is detected.	Does not prevent leak from developing. Does not stop leak upstream from transfer pump. Insensitive to small leaks.	Yes	No – Impractical (see additional discussion below)
Leak detection in sump/tank with alarms	Effectively warns workers of accident and transfer can be stopped.	Delay before leakage reaches sump. Relies on administrative controls. Insensitive to small leaks.	Yes	Yes
Physical barriers	Prevents damage to unloading station piping. Passive. Common industry practice.	Must be designed to prevent damage to the truck, which could lead to a spill.	Yes	Yes
Forced Ventilation	Effective in dispersing vapors.	May not be practical for this area. Unlikely to be needed for open area of unloading station. High maintenance demand on fans in open (dust burden, etc.)	No	No

Table 3.10-1. Nitric Acid Handling – Selection of Control Strategy Elements

Control	Advantages	Disadvantages	Compliance with Top Level Principles	Further Consideration in Control Strategy
Buddy System	Practical means of reducing risk. If an incident or injury occurred, help would be immediately available.	Requires additional person, possibility that second person gets injured.	Yes	Yes
Clear and complete written unloading procedures	Help ensure proper steps are taken each time delivery is made. Reduces risk from human error. This is a requirement of process safety management for this type of activity.		Yes	Yes
Monitor storage tank level	Easy to implement. Back up information – confirms acid arriving at destination. Common industry practice.	Relies on administrative measures to perform, and does not prevent an accident from occurring. Insensitive to small leaks.	Yes	Yes
Storage tank overfill detector and alarms/trips pumps	Helps prevent overfilling of the storage tank. Alerts operators without relying on their monitoring the level.	Relies on operator to take appropriate action.	Yes	Yes
Good housekeeping	Effective, common sense approach to eliminate potential interactions with combustible materials.	Relies on administrative controls to be effective.	Yes	Yes
Clean out sumps, empty of water and debris	Effective measure to prevent interaction in case of spill.	Relies on administrative action, does not prevent leak.	Yes	Yes
Flush area (in unloading procedure)	Prevent interaction with fine organics in spill area.	Administrative action; benefit may not warrant the additional work; creates additional wastewater that, if contaminated, would require disposal. Does not prevent leak from occurring.	Yes	No – Impractical (see additional discussion below)
Restrict personnel access during transfer	This should help reduce mishaps with unauthorized/untrained personnel in the area, and reduce potential exposure if spill occurs.	Relies on administrative measures.	Yes	Yes

The following provides additional discussion for some of the elements that were rejected.

- Sleeved Hoses and Fittings

  The strategy to apply sleeves to hoses and fittings was not carried further due to the impact on operability and maintainability. The application of sleeves to the hoses and fittings would have to be performed by the operators each time that a tanker was to unload. In order to make it effective, the sleeves would have to be drained to a repository; which would make the strategy difficult to maintain and cumbersome for the operators. There would be little gained beyond what is covered by the inclusion of PPE for the operators and the use of spray or splashguards. Therefore, they are not considered practical.

- Fittings and Connections with Pump Start Interlock

  Fittings and connections with pump start interlock would not preclude an accident downstream or upstream of these fittings. It would be an active feature that would be difficult to maintain and difficult to implement with subcontractor equipment. Further, this does not reduce the consequences of a leak during pumping. Therefore, this feature was dismissed as not fully effective, impractical and increases costs with no significant benefit compared to a positive locking coupling.

- Underground Tank

  The use of an underground tank to mitigate the consequences of a spill was not carried forward as a control strategy since it would introduce hazards of a different nature. To design an underground tank that would address this hazard, without introducing risks of other chemicals or water interacting with the acid, would be costly. The design would have to provide capabilities for detailed inspections of the interior of the tank and for thorough cleaning prior to each use, requiring confined space entry. The costs and risks associated with maintaining such a tank would offset its benefit. Therefore, it was considered impractical.

- Leak Detection with Auto Shutoff of the Pump

  The use of leak detection to automatically shut off the transfer pump as a control strategy was excluded at this time, because designing a system that could effectively stop the leak would be difficult, and because scenarios were presented in which stopping the pump could worsen the situation (such as an unisolable leak upstream of the pump for which continuing to offload the tanker could reduce the size of the spill). It was therefore considered ineffective. Additionally, the fact that unloading a tanker is a manned operation led to selection of remote access emergency shutoff, which is more reliable and easier to maintain.

- Flush the Area

  When evaluated against the operability criteria, flushing the area prior to unloading the tank was dismissed. Flushing will create an unnecessary effluent for no significant benefit compared to those achieved by good housekeeping. Good housekeeping practices were deemed sufficient to reduce the material that could react with the nitric acid.

Still being considered as control strategies are the following elements:

Hardware Elements

- Positive locking couplings
- Excess flow shutoff valve
- Remote access emergency shutoff
- Berm around tanker/Truck sump with pump
- Leak detection in sump with alarms
- Physical barriers between truck and unloading station piping and equipment
- Storage tank level indication/Storage tank overfill detector with alarm
- Tanker Truck standards [49CFR171-180]
- Personnel Protection Equipment [29CFR1910.132]
- Spray or Splash Shields [29CFR1910.132]
- Eyewashes and showers [29CFR1910.151 (c)]

Administrative Elements

- Establish buddy system
- Provide clear and complete written unloading procedures
- Monitor storage tank levels
- Practice good housekeeping
- Keep sumps empty of water and debris
- Restrict personnel access during transfer
- Emergency Procedure [29CFR1910.119]

3.10.3.2.2 Step 2 (Engineering Screen)

The preferred strategies were then developed through an engineering evaluation of the hardware alternatives. Administrative measures and controls were not reviewed in this engineering screen, since their nature tends not to impact design elements. Additionally, those elements required by law were also not included in the engineering screen, since they will be categorically adopted. This review took account of the following considerations to ensure a comprehensive approach in the context of other hazards and the overall design.

- Introduction of secondary hazards

- Impact on safety features provided to protect against other hazards

- Impact of other hazards upon the control strategy

- Robustness to other fault conditions and environments (including seismic and other design basis events)

- Passive or active, if active automatic or administrative/procedural – order of preference
- Robustness of any administrative controls required
- Cost
- Operability
- Maintainability
- Ease of justification (e.g., consistency with proven technology)

The considerations are presented in Table 3.10-2.

Table 3.10-2. Engineering Evaluation

Criterion	Berms and Sumps	Positive Locking Coupling	Excess Flow Shutoff Valve	Leak Detection in Sump with Alarm	Tank Level and Overfill Alarm	Physical Barriers	Remote Emergency Shutoff
Introduces Secondary Hazards	Yes – tripping hazards, but acceptable in consideration to the consequences of a spill	No	No	No	No	No	No
Impact on Safety Features Provided to Protect Against Other Hazards	None	None	None	None	None	None	None
Impact Of Other Hazards Upon The Control Strategy	None	None	None	Impacted by loss of power	Impacted by loss of power	None	None
Robustness To Other Fault Conditions And Environments	Yes – If seismically qualified	Yes	Yes	No – sensitive to loss of power	No – sensitive to loss of power	Yes	Yes
Passive Or Active	Passive	Passive	Active, automatic	Active, alarm is automatic, but operator response required	Active, alarm is automatic, but operator response required	Passive	Active, administrative, would be applied in conjunction with leak detection alarms and overfill detection/alarms
Robustness Of Any Administrative Controls Required	No significant complexity	No significant complexity	No significant complexity, well understood	No significant complexity	No significant complexity	No significant complexity	No significant complexity, well understood

Table 3.10-2. Engineering Evaluation

Criterion	Berms and Sumps	Positive Locking Coupling	Excess Flow Shutoff Valve	Leak Detection in Sump with Alarm	Tank Level and Overfill Alarm	Physical Barriers	Remote Emergency Shutoff
Cost	No significant cost increase	No significant cost increase	No significant cost increase	No significant cost increase	No significant cost increase	No significant cost increase	No significant cost increase
Operability	Well proven, recommended in industrial practice	Well proven	Well proven, recommended in industrial practice	Well proven	Well proven	Well proven	Well proven, recommended in industrial practice
Maintainability	Must be kept clean, easy to maintain	Easy to maintain	Should be periodically tested	Inclusion of detectors will require additional maintenance activity	Inclusion of detectors will require additional maintenance activity	Easy to maintain and test	Easy to maintain and test
Ease Of Justification	Proven, much experience	Proven technology	Proven technology	Proven technology	Proven technology	Proven technology	Proven technology
Consider Further	Yes	Yes	Yes	Yes	Yes	Yes	Yes

3.10.3.2.3 Control Strategy Conclusions

The selected control strategy elements, which together constitute an overall control strategy, are:

Hardware Elements

- Positive locking couplings
- Excess flow shutoff valve
- Remote access emergency shutoff
- Berm around tanker/Truck sump with pump
- Leak detection in sump with alarms
- Physical barriers between truck and unloading station piping and equipment
- Storage tank level indication/Storage tank overfill detector with alarm
- Additional elements required by law:
  - Tanker Truck standards [49CFR171-180]
  - Personnel Protection Equipment [29CFR1910.132]
  - Spray or Splash Shields [29CFR1910.132]
  - Eyewashes and showers [29CFR1910.151 (c)]

Administrative Elements

- Establish buddy system
- Provide clear and complete written unloading procedures
- Monitor storage tank levels
- Practice good housekeeping
- Keep sumps empty of water and debris
- Restrict personnel access during transfer
- Additional element required by law:
  - Emergency Procedure [29CFR1910.119]

See Figure 3.10-3 for a sketch of the control strategy elements.

Many of the design features listed as the control strategy were common practices within the chemical industry. For instance, the excess flow shutoff valve, remote access emergency shutoff, truck sump, physical barriers and storage tank level were all recommended by those designing systems for the chemical storage industry. Good practices for administrative measures were to establish a buddy systems and maintain good housekeeping.

3.10.3.3 Structures, Systems, and Components that Implement the Control Strategy

SSCs that implement the selected control strategy for the nitric acid handling hazard are:

- Tanker designed and qualified to meet DOT requirements to haul nitric acid, in order to prevent potential spills due to the use of improper equipment.
- Berms and sumps to confine and collect any spill, to prevent interaction of nitric acid with nearby chemicals, and to prevent leakage to the ground.
- Spray or splash shields and walls to confine the potential spray of acid, in order to protect the worker and to isolate the nitric acid from chemicals with which it would interact.
- Positive locking coupling to avoid leakage at the coupling for transfer.
- Excess flow shutoff valve to stop transfer it there is a large break downstream of the valve.
- Detection in the sumps and bermed areas, and alarms, to provide warning for emergency action to mitigate the potential consequences of a spill.
- Storage tank level and overfill detector with alarm to warn of the potential tank overfill.
- Physical barriers between the tanker and the unloading station piping and equipment to prevent damage.
- Remote emergency shut off of the transfer pump to provide the ability to stop the transfer pump outside the spill area.
- Eyewashes and showers for mitigating contamination of a worker with nitric acid.
- PPE for worker protection.

A summary of the control strategy and associated SSCs is provided in Table 3.10-3.

3.10.4 Safety Standards and Requirements

3.10.4.1 Reliability Targets

Reliability targets do not apply to this evaluation as deterministic arguments are used when deciding if additional control strategies are required above those accepted as common industry practice.

3.10.4.2 Performance Requirements

The berms and the sumps must be able to contain the entire contents of the storage tank or tanker, depending on where the spill occurs. The deeper the sump in the tanker unloading station, the smaller the surface area of the spill, which will help to mitigate the downwind consequences of the spill as well as contain the spill and protect the environment. Additionally, the berms, sumps, and concrete unloading pad must be coated to protect them from acid spill and to prevent leaks, which might lead to degradation of the structures.

The personal protective equipment (PPE) must be selected for acid compatibility and in accordance with the MSDS.

Spray or splash shields are needed in the event that a spray occurs as part of the leak. The spray or splash shields need to completely prevent the occurrence of chemical interactions. They need to be made out of a material that will not deteriorate in outdoor conditions or when exposed to a nitric acid spray.

The eyewash and shower station must be located in proximity to the workers and available when working with the chemicals. Proper pressure must also be available to ensure proper operation of the eyewash and shower when needed.

The process hardware, such as the hose, pumps, and piping, must meet the industry standard for the designed duty, including acid compatibility, flushing capability, and design pressures and temperatures.

Alarms and detection must be available continuously, which requires that they have an uninterruptible power source. Alarms need to be audible in the effected areas of a potential spill and to trigger in time for evacuation to occur before a serious risk to worker health is reached.

Positive locking couplings should be incorporated so that the operator making the connections can positively determine that the coupling has been properly made and is secure. This will prevent leakage through the coupling or disconnection of the coupling during transfer.

The excess flow shutoff valve should be sized to prevent the excess flow of fluid during pumping. The valve needs to be sized such that it does not restrict the normally anticipated flow during a transfer.

The remote access emergency shutoff capability must be located so that the operators may respond to the spill or spray without jeopardizing their own safety.

The design for physical barriers needs to be able to withstand a truck impact without causing substantial damage to the tanker. The are between physical barrier and the unloading piping and hardware needs to be such that the damage to the guard posts will not cause damage to the transfer piping and hardware.

3.10.4.3 Administrative Measures

In transferring chemicals from a tanker to a storage tank, there are several administrative measures that have been identified as being necessary to ensure a safe transfer of material. **Operational Assumptions.**

Prior to the tanker being allowed into the unloading station, the unloading station sump must be cleared of organic material, fluids, and debris that would inhibit its performance or interact with collected acid. Any fluids in the sump must be sampled prior to disposal to determine the proper disposal method for the contents of the sump.

The unloading must not be permitted if power is not available to the unloading station, or if the eyewash and safety shower are not functional. The workers must be briefed and have the MSDS made available to them.

Operations of chemical transfer must be carried out by trained individuals. They should be trained on the unloading procedures, safety requirements, MSDS, spill response, and emergency response procedures. The written procedures must be available to the operators during the chemical transfer.

Operations should confirm that the storage tank has sufficient margin to receive the contents of the tanker or have specific procedures and equipment to protect against overfilling. If the contents of the tanker could exceed the capacity of the storage tank, this will need to be addressed during the design phase to ensure that there are sufficient controls to prevent overfilling the tank.

The workers that are involved with the transfer operation will be required to wear the appropriate PPE in accordance with the MSDS for nitric acid. This is for the workers protection since many of the chemical exposures that occur in occupational settings are not from catastrophic failures, but from small leaks or sprays during the connection and disconnection phases of the transfer operation.

Operations should not commence if an identifiable natural phenomena hazard is likely, e.g. temperature extremes, volcanic ashfall, etc.

After the tanker arrives at the site, prior to initiating the unloading process, the operator will be required to confirm the qualifications of the tanker to ensure that it meets the DOT requirements for a tanker shipping nitric acid (i.e. inspect and confirm that the certifications presented by the driver are complete and current). The driver of the tanker will also have operating procedures that will need to be followed and coordinated with the site operator to ensure that there will be no disconnect between the responsibilities. The TWRS-P operator will need to verify that the hose that the tanker uses has been properly pressure tested. A proper pressure test will ensure that there are no leaks and help to confirm the adequacy of the assembly of the hose.

Prior to unloading the tanker contents into the storage tank, the contents shall to be sampled to verify that it is nitric acid that is being unloaded. Mixing chemicals within the storage tank could produce violent reactions with undesirable consequences.

Lastly, the emergency response procedures need to be available, and personnel that could be potentially affected by the spill need to be trained and drilled on the actions required by the procedures. The procedures need to address the areas that require evacuation for the maximum expected size of spill. Notification of the proper authorities must also be noted in the procedures.

During the development of detailed unloading procedures, industry good practices will be researched and incorporated into the procedures to provide added assurance that the transfer will be performed safely.

3.10.4.4 Administrative Standards

Operation of the TWRS facilities shall be conducted in accordance with proven practices from BNFL operations in the UK and the US. Arrangements will be in place to maintain and demonstrate compliance with all Safety Criteria detailed within the authorization basis.

Administrative arrangements will provide the framework for how facility operations will be conducted for all modes of operation, be that normal, maintenance or emergency preparedness.

The conduct of operation guidelines will be generated by the tailored application of appropriate sections of the following standards:

DOE Order 5480.19, “Conduct of Operations Requirements for DOE Facilities.”
DOE Order 4330.4B, “Guidelines for the Conduct of Maintenance at DOE Nuclear Facilities.”

This framework of conduct will be implemented through:

- Management and organizational structure.
- Documents, records and certification, including response to abnormal operating conditions, key compliance recording and archiving.
- Structured training programs for all personnel, tailored to their roles and responsibility.
- Emergency preparedness implemented by having an emergency response structure, training, exercises and procedures.
- Incident reporting arrangements.
- Safety documentation hierarchy, with appropriate flow down of information into operational documentation. All safety implications will be clearly identifiable within the operational procedures.
- Quality assurance.
- Arrangements for the examination, inspection, maintenance and testing of all ITS equipment.
- Labeling of ITS equipment clearly on the facility.

3.10.4.5 Design Standards

The following is a listing of the applicable codes, standards and regulations that need to be applied and considered when designing a safe unloading station for nitric acid. Codes and standards were selected based on good industry practice. Many of the codes and standards are used as aids in implementing the regulations.

Design Guides / Codes

- ANSI/ASME B31.3 “Chemical Plant and Petroleum Refinery piping”. Nitric acid, piping category “M” Fluid service.
- ANSI Z358.1-1990 “Emergency Eyewash and Shower Equipment”.
- ANSI B36.19M “Stainless Steel Pipe”
- AIChE G31988 : “Guidelines for safe storage and handling of high toxic hazard materials”
- IEEE-446 “Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications”
- NFPA 70 “National Electrical Code”

- NFPA 801 “Standard for Facilities Handling Radioactive Materials”

- 29 CFR 1910/Subpart S “Occupational Safety and Health Standards, Electrical”

- UL 508 “Standards for Safety Electric Industrial Control Equipment”

Transportation

- 49CFR parts 171-180

Storage/ Handling

- NFPA 430 “Code for the storage of solid & liquid oxidizers”
- NFPA 231 “Standard for General Storage”
- NFPA 491M “Manual of hazardous Chemical Reactions”

Labor

- 29CFR 1910.119 “Process Safety Management of Highly Hazardous Chemicals”
- 29CFR 1910.120 “Hazardous Waste operations and Emergency Response”
- 29CFR 1910.132 – 138 “General Safety Requirements”
- 29CFR 1910.176 “Handling Materials - General”
- 29CFR 1910.307 “ Hazardous (Classified) Locations.
- 29CFR 1910.1000 “Air Contaminants”
- 29CFR 1910.1200 “Hazard Communication”

Structural

Note: The hazardous material spill evaluated in this example is not initiated by a natural phenomena hazard (NPH) event. The primary concern is for the concrete slabs, berms, and sumps. The NPH event loads will be determined in accordance with the following codes and standards.

- DOE-STD-1021, "Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities"

- UBC, "Uniform Building Code"

- ASCE 7, "Minimum Design Loads for Buildings and Other Structures"

- ACI 318, "Building Code Requirements for Structural Concrete"

3.10.4.6 Standards Not Cited in SRD

The following standards are not currently listed in the SRD (BNFL Inc. 1998d):

- ANSI Z358.1-1990 “Emergency Eyewash and Shower Equipment”

- ANSI B36.19M “Stainless Steel Pipe”
- AICHE G31988 “Guidelines for Safe Storage and Handling of High Toxic Hazard Materials”
- IEEE 446 “Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications”
- UL508 “Standards for Safety Electrical Industrial Control Equipment”
- NFPA 430 “Code for the Storage of Solid and Liquid Oxidizers”
- NFPA 491M “Manual of Hazardous Chemical Reactions”
- 29CFR 1910/Subpart S “Occupational Safety and Health Standards, Electrical”
- 29CFR 1910.119 “Process Safety Management of Highly Hazardous Chemicals”
- 29CFR 1910.120 “Hazardous Waste Operations and Emergency Response”
- 29CFR 1910.132 – 138 “General Safety Requirements”
- 29CFR 1910.176 “Handling Materials - General”
- 29CFR 1910.307 “ Hazardous (Classified) Locations”
- 29CFR 1910.1000 “Air Contaminants”
- 29CFR 1910.1200 “Hazard Communications”
- 49CFR Parts 171-180

3.10.5 Control Strategy Assessment

3.10.5.1 Performance Against Common Cause and Common Mode Effects

Administrative measures will be required to minimize the frequency of common cause and common mode effects as outlined in Section 3.10.2.5. **Operational Assumption**.

Natural phenomena hazard events could increase the likelihood of a nitric acid spill or increase the consequences, so transfer operations should not be carried out when natural phenomena hazard events can be predicted, as specified in Section 3.10.4.3. Protection against man made external events that could uniquely affect this facility has been provided in the selected control strategy (physical barriers and berms). Man made external events that affect the whole plant, such as aircraft crash, are discussed in Section 2.10. Protection of pipework against aircraft crash is not considered practical.

3.10.5.2 Mitigated Consequences

The mitigated consequences are considered to be negligible for the worker and the public summarized relative to the sequence of events developed in Section 3.10.2.2.

1. For worker getting sprayed – wearing PPE, or spray or splashshields in place, eyewash and shower available, the worker would not get burned.

2. Vapor evolves from spray or pool – trained worker, sump detection and alarm, worker wearing PPE, and emergency training response to evacuate area, the worker should not be overexposed.

3. Leak to ground – berm/trench and sump around tanker and connection station, housekeeping and cleaning of sump prevents leak to ground and fire potential.

4. Leak to dry chemicals and resins – spray or splashshields, berms and building walls, and distance precludes interactions and fire.

5. Potential to spray electrical equipment and instrumentation – future design to preclude adverse consequences. **Open Issue.**

6. Toxic gas enters buildings – future design and emergency response plans (ERPs) to preclude adverse consequences. **Open Issue.**

7. Protection of the co-located worker will require general employee training for site access.

3.10.5.3 Frequency of the Mitigated Event

Frequency estimates were not required since deterministic arguments can be used when applying mature control strategies in common industry practice. In addition, the ERPG-2 limits apply to chemical hazards rather than severity levels.

3.10.5.4 Consequences with Failure of the Control Strategy (Including Mitigation)

This is stated in Section 3.10.2.3

3.10.5.5 Frequency of the Control Strategy Failure

Frequency estimates were not required since deterministic arguments can be used when applying mature control strategies in common industry practice. In addition, the ERPG-2 limits applied to chemical hazards rather than severity levels.

3.10.6 Conclusions and Open Issues

3.10.6.1 Conclusions

A control strategy and associated SSCs and standards has been developed which is capable of providing an acceptable level of protection against the potential hazard of a nitric acid handling accident. The control strategy is summarized in Table 3.10-3.

3.10.6.2 Open Issues

A number of **Open Issues** have been identified for further investigation and resolution as part of design development. These are:

1. HVAC Intakes. The location of HVAC intake for other buildings, including the control room, should consider potential fume sources. This may prompt consideration of relocating the chemical storage tanks and/or unloading station to another area onsite.

2. Tank and Truck Sizes. The storage tank size must be finalized, and the potential of limiting the size of the delivery truck.

3. Hazard Analysis. A hazard analysis with respect to the entire wet chemical storage area must be performed.

4. Design Completion. Complete the design, i.e., pressures, line sizes, tank ventilation requirements, supporting equipment locations, etc.

In addition to the open issues listed above, various design and operational assumptions are highlighted in the report. Their continuous validity will be monitored through design development.

Table 3.10-3. Nitric Acid Handling - Control Strategy Summary

Hazard Description: Nitric Acid Spill During Tanker Unloading			**Initiator:** Pipe/Hose/Fitting Break		
Selected Control Strategy	**Important-to-Safety SSCs**	**Safety Functions**	**Design Safety Features**	**Design Assumptions**	**Operational Assumptions**
Tanker Truck					
Design Standards[1]	Tanker including transfer hardware	Ability to contain acid	Integrity of transfer system Qualified to hold acid	No design assumptions	No operational assumptions
QC / Administrative Standards[1]	None	Delivery of acid to correct specification	Driver has proper paperwork with him, e.g. MSDS and Bill of Lading	12.2M nitric acid	Vendor has a trained and qualified driver Operator checks delivery documents before unloading
Storage Tank					
Monitor Storage Tank Level	Level Indicator	Indicate level to operator, for operator action to prevent overfilling the tank or over-pressurizing the transfer piping	Procedures detail response to level indication Level indication visible to operator	Accurate during filling	Operators stop unloading prior to overfilling or over-pressurization conditions
Overfill Detector and Alarm	Detector and Alarm	Alarms prior to overfill	Alarms at approximately 80% full Detectors and alarms have UPS	Properly functions during filling	Operators stop unloading prior to overfilling or over-pressurization conditions
Unloading System					
Berm	Berm	Retain contents of tanker Accepts entry of tanker without losing confinement	Designed to hold contents of tanker with margin Liner or coating compatible with acid	Tanker does not exceed 5,000 US gallons (19 m^3)	No operational assumptions
Positive Locking Coupling	Coupling	Prevents leakage	Leak proof seal Positive locking	Tight seal against highest pressure	Seal routinely maintained, inspected and tested
Excess Flow Shutoff Valve	Valve	Shut off flow of nitric acid for flow rates in excess of the design	Size the valve properly considering normal operating surges; of proven design	Valve is designed to be compatible with assigned duty, i.e. fluid type, pressure, temperature, operating conditions, shutoff flow	Appropriate maintenance of valve is performed
Remote access emergency shutoff	Wiring from transfer mechanism to emergency shut off Protection from possible spray (see Spray or Splash Shields)	Shut off the transfer mechanism upon detection of spray or spill	Located such that the workers may respond to spill or spray without jeopardizing themselves	No design assumptions	Operators can visually detect spill or spray. Operators are trained on emergency response to spill or spray

Table 3.10-3. Nitric Acid Handling - Control Strategy Summary

Hazard Description: Nitric Acid Spill During Tanker Unloading			**Initiator:** Pipe/Hose/Fitting Break		
Selected Control Strategy	**Important-to-Safety SSCs**	**Safety Functions**	**Design Safety Features**	**Design Assumptions**	**Operational Assumptions**
Unloading System, cont.					
Truck sump with Pump	Sump (pump facilitates cleanup only)	Retain contents of tanker	Designed to hold contents of tanker with margin Liner or coating compatible with acid Sumps are designed such that they can be cleaned and emptied	Pump is connected to an acceptable storage location for acid Sized with berm to hold > 5,000 US gallons (19 m^3)	Sump is confirmed as clean and empty prior to truck arriving
Leak detection in sump with alarms	Level Detector in Sump Alarms to warn personnel Alarm in Wet Chemical Storage Area Control Room	Alert operators and personnel to off-normal condition	Detector and Alarms have Uninterruptible Power Source Alarms are audible in affected areas Detector and Alarms trigger in time for action to occur before serious injury	Detection is of sufficient sensitivity to perform the safety function	Operators are trained on emergency response to spill or spray to activate emergency shutoff Manned Wet Chemical Storage Area Control Room during transfer
Spray or Splash Shields[1]	Shield	Restrict chemical spray at connection points	Chemically compatible Weather resistant Contain spray or spill with path to berm or sump	Fixed configuration w/o need for operator to erect	No operational assumptions
Physical Barriers	Metal / concrete posts or walls	Prevent physical impact to unloading station permanent transfer piping	Designed with enough room between the posts and the unloading station that the transfer piping will not be damaged Designed such that the post will not cause critical damage to the tanker truck.	Withstand truck impact	Operators will not transfer acid if posts become damaged, as delineated by detailed unloading procedures
Personnel Protection					
PPE[1]	PPE	Protect workers from spray or spill of acid	PPE as delineated on the MSDS Purchased for acid compatibility	No design assumptions	Operators are trained on wearing PPE
Eyewash and Showers[1]	Showers, eyewash station with water supply.	Remove acid from PPE (and personnel if necessary)	Available with sufficient pressure Oriented and configured for effectiveness Maintained Provide for freeze protection	Meet code requirements	Verify operational prior to nitric acid transfer Operators familiar with use

Table 3.10-3. Nitric Acid Handling - Control Strategy Summary

Hazard Description: Nitric Acid Spill During Tanker Unloading			**Initiator:** Pipe/Hose/Fitting Break		
Selected Control Strategy	**Important-to-Safety SSCs**	**Safety Functions**	**Design Safety Features**	**Design Assumptions**	**Operational Assumptions**
Administrative Measures					
Buddy system	None	Provide aid to worker, if spill/spray occurs Able to carry out emergency response measures	All personnel used for the transfer of nitric acid are trained and briefed on the required tasks and emergency responses	No design assumptions	Properly trained operators Two persons required for unloading
Emergency Planning Procedures[1]	None	Protect facility and co-located workers and emergency response personnel from overexposure to toxic gas	Provide protection for the expected range of spills	No design assumptions Control room/building habitability is an **Open Issue**.	Personnel are trained to and drilled on the procedure. Includes notification of proper authorities
Detailed Written Unloading Procedures	None	Convey safety information and process details to assure a safe transfer of nitric acid	Personnel are trained to the written unloading procedures	No design assumptions	Procedures are validated prior to use
Good Housekeeping Clean out sumps, empty of water and debris	None	Prevent interaction of nitric acid with organics, potential combustibles and debris, water or other chemical residue	Expectations are clearly communicated to workers Metrics for cleanliness are established in accordance with the hazard	No design assumptions	No operational assumptions
Restrict personnel access during transfer	None	Protect facility workers from entering potentially hazardous area unaware	Barrier around potential spray area Personnel trained on meaning and response to barrier	Barrier design facilitates truck entry, personnel adherence, and ease of use	Erection of temporary barriers performed Compliance with restrictions
Stop Transfer is predictable natural phenomena hazard is likely	None	Minimizes possibility of leaks caused by damage from wind missiles, flooding, snow, temperature extremes. Minimizes consequences of chemical reaction with foreign items if leak occurs.	None	None	Correct procedures

[1] – Required by Law or Regulation

References

AIHA, 1988, *Emergency Response Planning Guidelines*, American Industrial Hygiene Association, Akron, Ohio.

BNFL Inc., 1997a, *System Design Description, Cold Chemical Systems*, dated 10/8/97, BNFL Inc., Richland, Washington.[a]

BNFL Inc., 1997b, *Tank Waste Remediation System Privatization Project, Hazard Analysis Report*, BNFL-5193-HAR-01, Rev. 0, BNFL Inc., Richland, Washington.

BNFL Inc., 1998c, *Tank Waste Remediation System Privatization Project*, *Initial Safety Analysis Report*, BNFL-5193-ISAR-01, Rev. 0, BNFL Inc., Richland, Washington.

BNFL Inc., 1998d, *Tank Waste Remediation System Privatization Project*, *Safety Requirements Document*, *Volume II*, BNFL-5193-SRD-01, Rev. 2, BNFL Inc., Richland, Washington.

BNFL Inc., 1998e, *Preliminary Safety Review of TWRS-P Bulk Cold Chemical Storage Systems*, BNFL-5193-RPT-006, Rev. 0, BNFL Inc., Richland, Washington.[a]

Craig, Douglas K., 1998, *ERPGs and TEELs for Chemicals of Concern*, Rev. 14 Abbreviated, WSMS-SAE-98-00101, Westinghouse Safety Management Solutions, Aiken, South Carolina.[a]

DOE-RL, 1998b, *Contract Number DE-AC06-96RL13308*, U.S. Department of Energy, Richland Operations, Richland, Washington.

DOE-RL, 1998c, *Top-Level Radiological, Nuclear, and Process Safety Standards and Principles for TWRS Privatization Contractors*, DOE/RL-96-0006, Rev. 1, U.S. Department of Energy, Richland, Washington.

Eager, K., 1999, *Usage Rate of Purchased 12.2 Molar Nitric Acid*, Calculation No. CALC-W375PT-PR00008, BNFL Inc., Richland, Washington.[a]

Mallinckrodt Baker, Inc., 1996, *Material Safety Data Sheet for Nitric Acid*, MSDS Number: N3660, 12/08/96, Phillipsburg, New Jersey.[a]

Page, M., Roberts, R., Isherwood, J., Wright, S., Shea, P., and Boomer, K., 1998, *Basis of Design*, DB-W375-EG00001, Rev. 0, BNFL Inc., Richland, Washington.

Roberts, 1997, *Memo: Transmittal of Sketches*, CCN 000217, 9/18/97, BNFL Inc., Richland, Washington.[a]

Schulz, J., 1999, *Nitric Acid Spill Toxic Chemical Consequences*, Calculation No. CALC-W375BF-SA00002, BNFL Inc., Richland, Washington.[a]

[a] Copies of these references accompany this deliverable.

Washington State Building Code Council, 1995, *Washington State Building Code, Uniform Building Code and Uniform Building Code Standards*, Washington State, Olympia, Washington.

Figure 3.10-1. Process Diagram for Nitric Acid

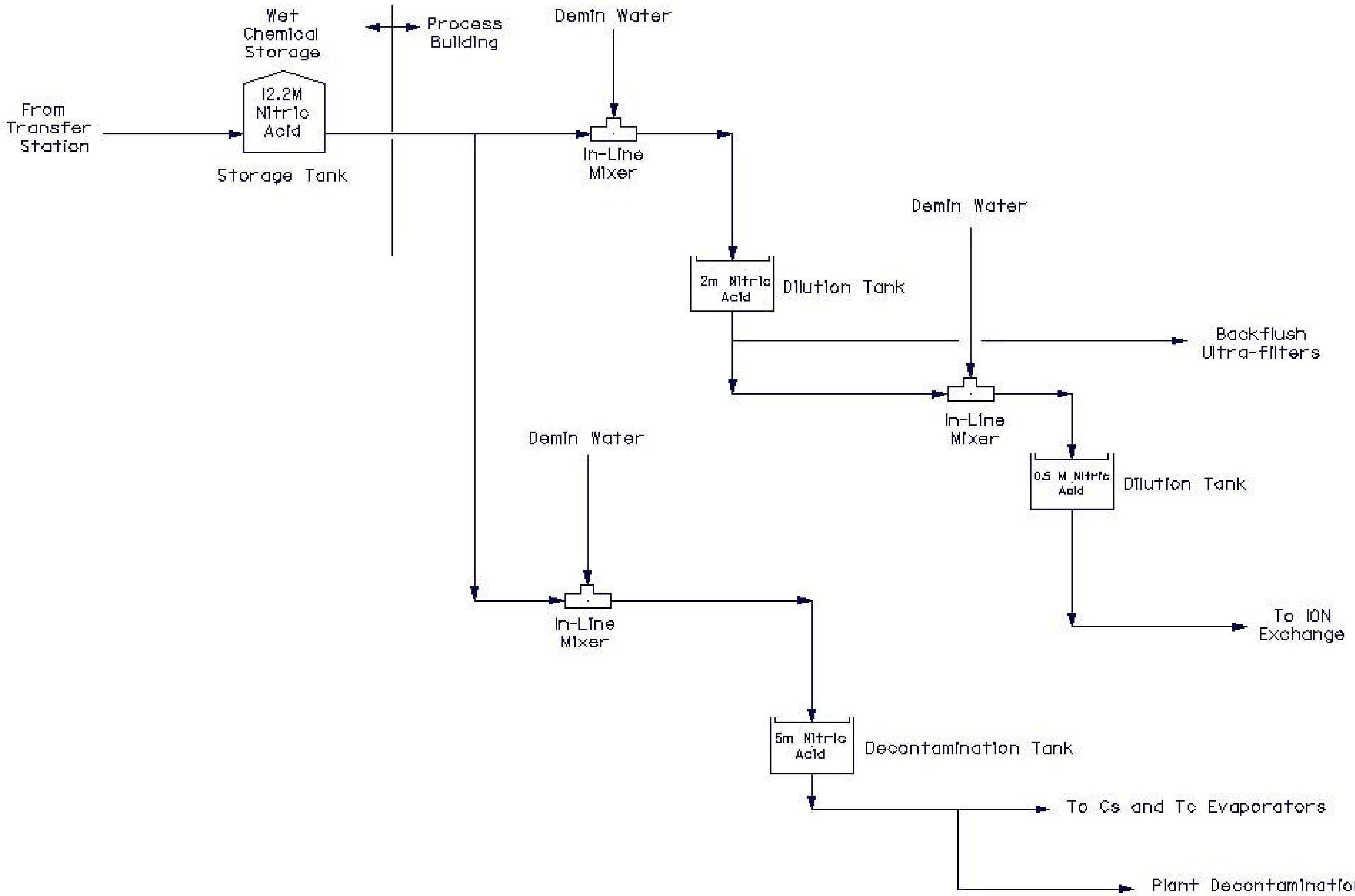

Figure 3.10-2. Preliminary Plant Layout

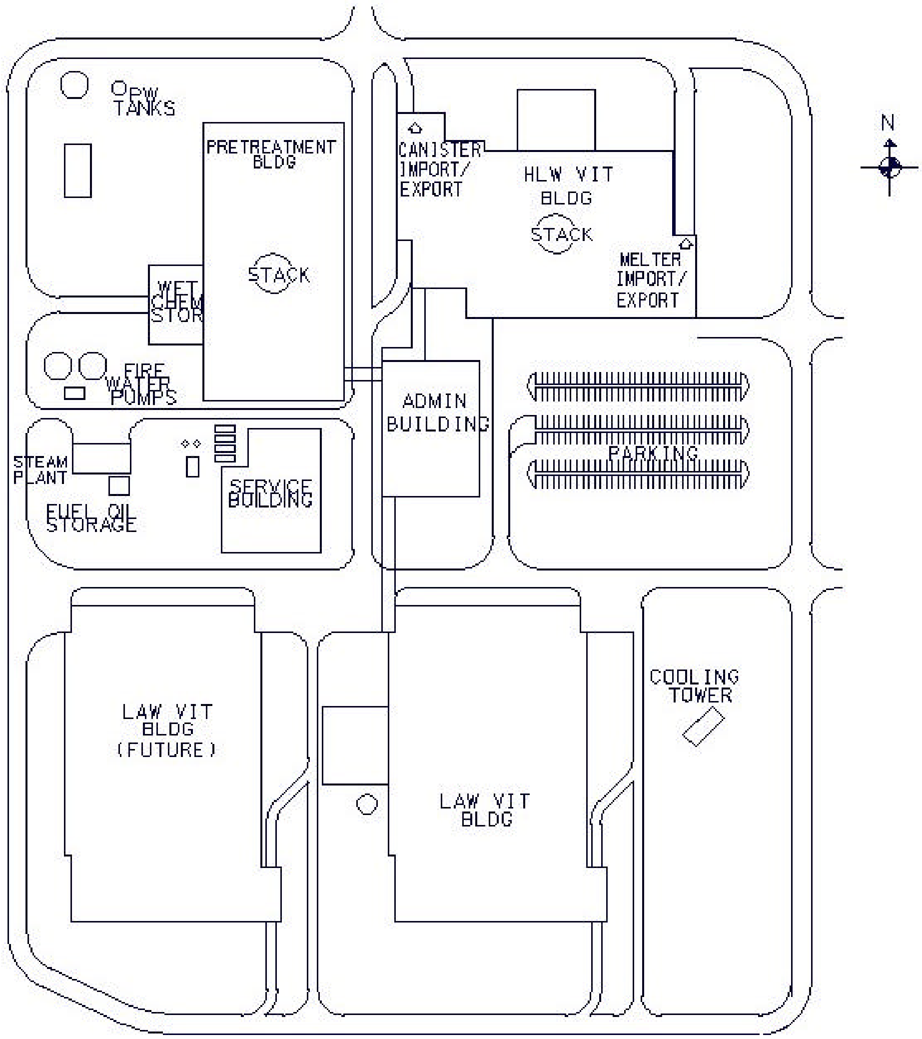

Figure 3.10-3. Control Strategy Sketch